WEST AFRICAN COCOA RESEARCH INSTITUTE

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No. 40

TAFO, GOLD COAST.

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WEST AFRICAN COCOA RESEARCH INSTITUTE
TAFO

FORTIETH QUARTERLY REPORT : OCTOBER-DECEMBER, 1955

SENIOR STAFF

Director	:	J. Lamb (arrived 1st November)
Deputy Director	:	A. Pickles (transferred 16th November)
Secretary	:	G. H. Neal

TAFO STATION

Division of Entomology	:	D. J. Taylor (returned 2nd October) F. Raw P. B. Cornwell (on leave 7th December) F. E. Decker P. F. Entwistle
Division of Pathology	:	W. T. Dale (returned 24th October) A. L. Wharton (on leave 9th December) G. Usher A. Attafuah
Division of Botany	:	A. D. McKelvie
Division of Soil Science and Chemistry	:	T. A. Rohan E. Margaret Holden S. N. Adams (on leave 12th October)
Division of Agronomy	:	R. J. Benstead
Station Manager	:	S. E. Ntim-Kwafo (returned 1st September)

IBADAN SUB-STATION

Acting Officer-in-charge	:	J. Nicol
Entomologist	:	R. G. Donald (returned 5th October)
Pathologists	:	R. M. Lister J. M. Thresh (returned 12th November)

STAFF MATTERS

Mr. J. Lamb assumed duty as Director on 1st November and Mr. A. Pickles left on 16th November to take up his appointment as Secretary for West African Agricultural and Forestry Research. Dr. S.N. Adams, Mr. R. Wickens and Mr. J.F. Archibald have all left the Institute for appointments with Rothamsted Experimental Station, the British Ministry of Agriculture and the Uganda Department of Agriculture, respectively.

The Director visited the Ibadan Sub-station in December and Mr. R.G. Donald from the Sub-station visited Tafo in November..

MANAGING COMMITTEE

The Managing Committee held its eighteenth meeting at Tafo on 6th and 7th of December, and a meeting of the Technical Sub-Committee took place the following day.

VISITORS

Mr. G.W. Nye (Deputy Agricultural Adviser to the Secretary of State for the Colonies), Mr. P.C. Chambers (Director of Agriculture, Northern Nigeria), Mr. G.S. Cotterell (Senior Entomologist, Federal Department of Agricultural Research, Nigeria), Mr. R.R. Panje (India) and the Secretary and four Members of the Western Region (Nigeria) Marketing Board have visited the Tafo Station during the quarter. Other visitors included three members from the International Office of Cocoa and Chocolate (Messrs. H.C. Lichti, J.S. van Mesdag and T. Feldmann), a party from the International Trade Union Seminar, Messrs. Acton and Redmayne (Director and Assistant General Manager, Bank of British West Africa Limited), Mr. R.W. Leonard (Director of Messrs. J.S. Fry) and Mr. C.M. Carr, Managing Director of Plant Protection Limited, accompanied by three members of his staff. Visitors to the Ibadan Sub-station included the Minister of Research and Information, Federation of Nigeria, and Mr. C.M. Carr.

MANAGEMENT AND MAINTENANCE

The new laboratory building at the Ibadan Sub-station is now roofed and much of the internal and external plastering has been completed. The gas-plant and fume-cupboards ordered through the Crown Agents have arrived.

The average daily production and consumption of water at the Tafo Station were as follows :-

	Production	Consumption
October ..	18,316 gallons	16,516 gallons
November ..	23,657 "	22,990 "
December ..	22,527 "	21,764 "

Samples of water sent for analysis were reported to be free from pollution of any sort.

CROP .../

CROP DELIVERY

Very little cocoa remained on the trees by the end of the quarter. Harvesting being incomplete, Tables are not presented, but the following trends are apparent :-

(i) Black pod disease, as indicated by the percentage of pods discarded at fermentation, was less prevalent than at the same time last year, due probably to more rigid adherence to a weekly harvesting programme (see Section 3a of this Report).

(ii) Overall yield would appear to be slightly better than last season, but due to the abnormal presentation of crop it would be unwise to regard this assumption as definite.

(iii) Pod size, as indicated by pods per lb. of wet beans, was larger than that for last season (4.81 as against 5.15).

SWOLLEN SHOOT DISEASE INCIDENCE

Trees removed during treatment for swollen shoot disease are shown below :-

Station		Oct.	Nov.	Dec.	Total
Old Station		21	36	22	79
Square Mile	(Diseased	200	129	134	463
	(Suspects & Contacts	37	40	47	124
Adonkwanta		-	1	1	2
Akwadum		3	2	3	8
Nankese		-	-	-	-
Kukua		-	-	-	-
Koransang		47	-	1	48

In addition, 33 diseased seedlings were removed from the Old Station rehabilitation areas. The high incidence at Koransang indicates the difficulty of eradicating the disease when planting and cutting out take place concurrently. On the Old Station 15 mature trees were lost from causes other than swollen shoot disease.

OUT-STATIONS

A considerable amount of capsid damage has been observed on all farms where a poor canopy exists, and in contiguous areas. These attacks are being dealt with by the

Entomology .../

Entomology Division team as soon as they become evident, and treatment is continued until a complete canopy is formed.

Harvesting has been more or less completed, except at Kukua and Koransang where some branch crop remains.

IMPROVED PLANTING MATERIAL

So far this season, 1,785 F2 and 10,194 F3 pods of approved Upper Amazon types have been sent, for seed, to the Agricultural Departments of Eastern and Western Nigeria and the Southern Cameroons. Almost all consignments have been by air. A total of 3,954 F2 pods has been supplied to the Gold Coast Department of Agriculture.

METEOROLOGY

Rainfall for all stations is given below :-

Station	Rainfall in inches				Wet days			
	Oct.	Nov.	Dec.	Total	Oct.	Nov.	Dec.	Total
Tafo Station	17.95	1.73	3.77	23.45	25	11	9	45
" 17-yr mean	8.73	4.20	2.26	15.19	18.1	10.6	5.9	34.6
Adonkwanta	10.88	2.16	2.55	15.59	11	4	5	20
Akwadum	10.45	4.57	5.01	20.03	21	9	6	36
Nankese	12.50	4.26	4.01	20.77	14	7	6	27
Kukua	9.77	.96	2.55	13.28	13	4	5	22
Koransang	7.88	1.52	2.69	12.09	11	4	4	19

A shade minimum temperature of 54°F. was registered on 29th December, the lowest since January 1948, when 53°F. was recorded.

RESEARCH WORK

The accounts which follow are arranged in the order set out in the approved Research Programme. Certain lines of work, particularly Experiments on Establishment and Maintenance (Section 5), Soil Fertility and Manurial Requirements (6), and Plant Breeding and Selection (8), have suffered through resignations of Research and Technical Staff. Every effort is being made to carry on existing experiments, but no new work on these projects can be started until the staff position improves.

The Annual Report for 1954-55 and "Proceedings of the West African International Cacao Research Conference, Tafo, December 1953" have been published during the quarter.

TAFO .../

TAFO STATION

1. VIRUS RESEARCH

(a) Host Range of Cacao Viruses

There is still no evidence of virus infection in Adansonia digitata L. within the cacao areas of the Gold Coast itself; but on a recent visit to Wusuta in British Togoland a regenerating stump showing highly suggestive symptoms was found about a hundred and fifty yards from an outbreak of cacao virus of the Kpeve type. The results of back-tests on this material and some collected at Kpeve are awaited with interest. There is a great resemblance between symptoms of the Kpeve cacao virus and those produced in cacao by the Adansonia isolates AD7 and 14; AD36 gives milder symptoms of the same type.

The transient red mottling in cacao test plants colonized with mealybugs previously fed on material from two trees of Sterculia rhinopetala K. Schum. (see 39th Quarterly Report) appears not to have been due to a virus but to a genetical abnormality. Further tests on the two trees have given negative results and similar symptoms have since been observed on cacao seedlings used in an entirely different experiment.

In laboratory tests, Sterculia appendiculata K. Schum. ex Engl. from Tanganyika, S. rubiginosa Vent. from Singapore and S. alata from Ceylon have proved susceptible to the New Juaben cacao virus, and the first to the Kpeve virus also. Heliocarpus popayanensis from Trinidad, already shown to be susceptible to the New Juaben virus (see 38th Quarterly Report), has now been infected with the one from Kpeve, which is more like the Trinidad cacao virus isolates. A type of Ceiba (? pentandra Gaertn.) devoid of spines and with unusually long fruits, seed of which was obtained from Nsawam, is susceptible to the New Juaben virus. The initial symptoms on seedlings were marked, but (as with the common Eastern Province type of C. pentandra) later formed leaves were symptomless. Theobroma bicolor Humb. and Bonpl. has been infected with the Adansonia virus AD7 and (by grafting) with the Asalu cacao virus from Nigeria. Three varieties of jute received from the Department of Agriculture, Kumasi, have proved susceptible to the New Juaben virus. All three appear to belong to Corchorus olitorius L., though one has longer and narrower leaves and a more upright habit than the other two.

(b) Insect Transmission Studies

The virus isolate from Peki has now been experimentally transmitted by Planococcus citri (Risso) as well as Pseudococcus njalensis Laing.

(c) Classification of Viruses and Virus Strains

No leaf symptoms associated with cacao virus outbreaks have been recognized in the Peki area; but when a virus from Peki Tsame Agato was experimentally transmitted to young plants by grafting, or to dissected beans by vectors, faint red-veining and fine chlorotic vein-flecking sometimes appeared on a few leaves.

An .../

An account of studies on the New Juaben (1A) cacao virus complex has recently been published by A.F. Posnette and J.M. Todd (Ann. appl. Biol., 43, p.433, 1955). They discuss (inter alia) the possibilities of mild-strain protection as a control measure. Of the various arguments against it, perhaps the most potent is that although mild strains can give protection against the effects of virulent ones they do not prevent their establishment in and dissemination from "protected" plants, a fact stressed by more recent results (see 38th and 39th Quarterly Reports).

Protection tests have shown that the Adansonia virus isolates AD7 and 36 are not closely related to the Mampong and Bisa cacao viruses; nor is AD14 to New Juaben.

(f) Chemical Detection of Cacao Virus Infection

Work has recently been resumed on chemical aspects of the Tinsley-Usher colour test, though routine testing of leaf samples has been discontinued. The substance responsible for giving a red colour on heating leaf extracts with alkali, and which (as previously reported) can be separated by paper partition chromatography, has the reactions of a leuco-anthocyanin. Chromatography on a column of cellulose powder is now being used to separate this leuco-anthocyanin in larger amounts.

Progress has been made in the chromatographic separation of the 'flavones' of healthy and infected leaves. In flush leaves chlorogenic acid, which although not a 'flavone' gives the same reaction with ammonia and fluoresces strongly in ultraviolet light, has been provisionally identified and appears to be present in high concentration.

A colour test based on the reduction of triphenyl tetrazolium chloride, which has been used elsewhere for detecting virus infection in other plants, is being investigated for possible application to cacao.

(h) Resistance to the New Juaben Virus

The Iquitos cacao plants that were 'bombarded' as dissected beans, none of which escaped infection following a second 'bombardment' as seedlings (35th Quarterly Report, et seq.), have been classified on the basis of tolerance to the virus. A few seemed almost as severely affected as West African Amelonado, many showed swellings and/or mild though quite obvious leaf symptoms, five have so far shown no symptoms at all, and the remainder only faint or transitory leaf patterns. Only those in the last two categories have been retained for further study.

The 'twinned' plants (36th Quarterly Report, et seq.) 'bombarded' once, as seedlings, with 150 'crawlers' of Pseudococcus njalensis have been similarly classified; six remain uninfected and three are, up to the present, symptomless carriers. A selection of plants with severe or intermediate symptoms, and their uninfested 'twins', have been retained for investigations as proposed in the 38th Quarterly Report (p.6, penultimate paragraph). There is obviously segregation for

tolerance .../

tolerance within these Iquitos progenies, though whether this is correlated with resistance to infection and low availability of virus to vectors remains to be seen.

In the first replication of the experiment to compare resistance in fifty Iquitos-type seedling trees (38th and 39th Quarterly Reports), the number of rooted cuttings from each becoming infected (using fifty 'crawlers' of Pseudococcus njalensis per plant, fed on a source of virus for 24 hours) has varied from one to five, the latter being the number of cuttings from each tree tested. The 'bombardments' in a second, identical replication are almost complete, and the cuttings for a third are being rooted.

2. MEALYBUG STUDIES

Experiments on mealybug movement and dispersal (a & b) started by Mr. Cornwell are continuing in his absence. He has recently written up for publication the results of his studies on the seasonal trends of mealybug populations in cacao under contrasting cultural conditions (c). The paper includes similar observations on mealybug-tending ants and on major mealybug parasites and predators.

(f) Mass-breeding of Mealybugs

In the second phase of this work, attention has been centred on creating ideal conditions for the establishment of attendant ants. The 'culturing room' has been made more airy by fixing wire gauze in the windows, in place of the original glass. Records of temperature and relative humidity, taken four times a day over a period of three months, have shown remarkably little variation around means of 77°F. and 94%, respectively. Successful establishment of both Crematogaster and Pheidole ants has been achieved under these conditions. The ants, which were first fed on sugar solution, readily transferred their attention to mealybugs as soon as colonies developed on the 'seed' potatoes which were used as host plants. So far, the limiting factor in the establishment of mealybugs has been the difficulty of providing favourable conditions for the potatoes. Treatment with perenox before planting almost entirely eliminated tuber-rot; but the spindly sprouts which developed were liable to tip-rot, and could not support heavy mealybug colonies for any appreciable length of time.

3. .../

3. STUDIES ON BLACK POD DISEASE

(a) Fungicide Control Trials

The harvesting records and pod-disease classification figures for Trial I at Bunso Plantations are summarized below :-

TREATMENT		PODS PER TREE								
Fungicide	Frequency of application	Total	Damaged	%	Black pods	%	Rodent damaged	%	Otherwise damaged	%
Unsprayed (Control)	-	20.95	6.94	33.1	3.61	17.2	2.26	10.8	1.08	5.2
Carbide Bordeaux	Frequent	25.81	4.56	17.7	1.27	4.9	2.41	9.3	0.88	3.4
	Monthly	22.83	5.44	23.8	1.56	6.8	2.65	11.6	1.23	5.4
Bordeaux Mixture	Frequent	30.40	7.21	23.7	2.19	7.2	3.18	10.5	1.84	6.1
	Monthly	25.32	6.30	24.9	3.17	12.5	2.85	11.3	0.27	1.1
Perenox	Frequent	25.79	6:27	24.3	1.89	7.3	3.34	13.0	1.04	4.0
	Monthly	21.64	6.12	28.3	2.33	10.8	2.49	11.6	1.14	5.3

More pods have been harvested this quarter than last, and little of the season's crop remains on the trees. Due no doubt to climatic factors, the incidence of black pod disease has been lower for all treatments, being less than half for the unsprayed plots. The actual numbers of infected pods in the sprayed plots were similar to those recorded last quarter. The fungicides have again substantially reduced the disease, and again 'frequent' spraying has given the best results; even though this treatment, which involves a spraying schedule based on the seasonal incidence of the disease, has consisted throughout most of the period of monthly applications. This, however, may not necessarily imply that the previous weekly or fortnightly spraying has produced a residual effect, since all the pods harvested this quarter were sprayed more frequently during part of their development. Considering the results for the three quarters as a whole, there is no doubt that carbide-Bordeaux mixture has proved the most effective fungicide. Over the last six months of 1955, at the frequent level of application, it has reduced the incidence of black pod disease from 30 to a little more that 5%; even when applied monthly it has given control as good as more frequent applications of ordinary Bordeaux mixture or perenox, the three treatments having about 10% incidence. The fungicides have had no appreciable effect on losses due to rodents or unclassified causes, depredations of the former remaining high.

Similar .../

Similar records for Trial II are given below :-

TREATMENT		PODS PER TREE								
Fungicide	Frequency of application	Total	Damaged	%	Black pods	%	Rodent damaged	%	Otherwise damaged	%
Unsprayed (Control)	-	14.42	3.82	26.5	1.75	12.1	1.12	7.8	0.95	6.6
Perenox	Fortnightly	11.61	2.29	19.7	0.78	6.7	1.16	10.0	0.35	3.0
	Monthly	16.67	3.43	20.6	1.91	11.5	1.02	6.1	0.50	3.0
Blitox	Fortnightly	11.95	2.60	21.8	1.16	9.7	0.99	8.3	0.45	3.8
	Monthly	11.39	2.18	19.1	0.80	7.0	1.05	9.2	0.33	2.9

These trees have not given any more pods than last quarter, but the incidence of black pod disease in the various treatments has fallen to between a half and a quarter of its previous level. Again, the fungicides have given a measure of control. Considering the results for the crop season so far, perenox applied fortnightly has reduced the incidence of the disease from 24 to 12%, and all the other treatments have reduced it to 17 or 18%. This quarter, unlike the last, the fungicides appear to have reduced the losses due to unclassified causes; but again they have had no effect on rodent damage.

Half the plots in both trials are harvested weekly and the remainder monthly. The figures below, which are 'black pods' expressed as percentages of all pods harvested, show the effect of these treatments in the sprayed and unsprayed plots :-

TRIAL I	Control (Unsprayed)	Carbide Bordeaux	Bordeaux Mixture	Perenox
Weekly harvesting	11.2	4.6	6.0	7.2
Monthly harvesting	26.2	7.1	13.2	11.1

TRIAL II	Control (Unsprayed)	Perenox	Blitox
Weekly harvesting	10.0	6.0	9.9
Monthly harvesting	24.3	14.6	7.1

Except .../

Except in the blitox-sprayed plots, weekly harvesting has markedly reduced the incidence of the disease, an effect shown in all treatments last quarter. The weekly harvested trees in Trials I and II have yielded 17% and 25% more total pods, respectively, than the monthly harvested ones. This unexplained phenomenon has been observed before (see 37th Quarterly Report).

(c) Cushion Infection

In the experiment to find out what proportion of proximal pod infections originate from diseased cushions (38th and 39th Quarterly Reports) 2,483 pods have been harvested from the 72 trees. Of these, 1,167 came from the 'accessible' parts and had been brush-painted weekly with a strong paste of perenox; 76 of them developed black pod disease, and in all but nine infection originated at the cushion (proximal) end. Of the remaining 1,316 'inaccessible' pods that were not brush-painted, 141 (10.7%) became infected, 64.5% of these from the proximal end. Assuming uniform incidence of the disease and the same ratio of proximal to distal and lateral infections in 'accessible' and 'inaccessible' parts of the trees, infection by mycelium from cushions was estimated at 1.93 pods per tree for the six months of the experiment. These assumptions, however, do not seem justified: for reasons connected with spread, germination and penetration of the fungus, more spore infections would be expected in lower ('accessible') parts of a tree; though an equal difference would not be expected for cushion infections, particularly as more cushions on 'inaccessible' parts may become infected, due to a greater tendency for 'black pods' to be left.

Fortunately, figures are available for nearby weekly harvested, unsprayed plots of Trial I, which it is felt may legitimately be used for comparison. The incidence of black pod disease in these plots was 31.7%, 60.6% of infections starting at the proximal end. This suggests that many more infected pods do indeed occur on 'accessible' parts of a tree, where the ratio of proximal to distal and lateral infections may be slightly lower. Combining both sets of figures, infection from cushions was assessed at 1.14 pods per tree, an estimate more likely to be accurate than the one given above. Incidence of this type of infection is likely to be closely correlated with cropping, having (unlike spore infection) little direct connection with climate. It is difficult, from this experiment, to obtain an accurate assessment of infection from cushions over a full season; but it probably amounts to 1.5-2.5 pods per tree, representing 3-5% of total pods, 10-20% of 'black pods' and 16-33% of proximal infections. The lower estimate, based on combined figures, is more likely to be accurate in each instance. Nevertheless, infections from cushions may be disproportionately important in carrying over the fungus from crop to crop, for they represent a higher proportion of total 'black pods' early in the season, when spore infection is low.

4. CAPSID STUDIES

(a) Capsid Pocket Regeneration Experiment

This experiment is proceeding satisfactorily. Dry-season coppicing has been carried out in the plots receiving this treatment and regular assessment of growth

and .../

and regeneration of all trees in the experiment is being made.

Insecticidal Studies

The need for more fundamental work on these lines has been emphasised by the results of experiments carried out by W.A.C.R.I. and the Gold Coast Department of Agriculture.

Capsid Rearing

In the past, biological and insecticidal studies have been hampered by the lack of a satisfactory method for rearing large numbers of capsid nymphs and adults under relatively standard conditons. A suitable laboratory method for mass-rearing Distantiella theobroma Dist. and Sahlbergella singularis Hagl. has now been developed. Adults are caged on basket seedlings for oviposition and, on hatching, the nymphs are transferred to, and reared on, unripe pods suspended in ventilated glass cages.

Toxicity of DDT and BHC to Capsids

No data have hitherto been available on the toxicity of DDT and BHC to capsid nymphs and adults. This is now being investigated, using capsids reared by the method described above. Pods are dipped in solutions of DDT and BHC of known concentration and the spray deposit allowed to dry. Capsids are then caged on the pods and the time taken to achieve 50% knock-down is recorded. Preliminary tests have shown that, at concentrations hitherto used in field trials, BHC has a much higher toxicity than DDT. In an experiment using first-instar D. theobroma nymphs 50% knock-down was achieved after 1 hour using 0.25% BHC, as against 5 hours using 2.5% DDT.

Persistence of Insecticides

Experiments to investigate the persistence of DDT and BHC deposits on cacao foliage under field conditions, using Tribolium castaneum Hbst. as test insect, are continuing.

Repellency of BHC and DDT to Capsids

Laboratory experiments have been conducted to study this effect in relation to cacao capsids but no significant result has so far been obtained. The problem is still under investigation and field experiments during the coming year are proposed.

Ovicidal Properties of BHC

Laboratory tests have recently been started to investigate the effect of BHC on capsid eggs. Eggs are obtained by caging adult capsids on seedlings in the laboratory, and are treated in situ. Treatments have included low volume spraying, and dusting. No results are available as yet.

(e) .../

(e) Combined Cultural and Insecticidal Control
Dusting and Pruning Experiments

In this series of experiments a method of capsid control consisting of the localised application of insecticidal dust to recently damaged trees is being compared with a routine application of liquid insecticide. The experiments were laid down on Amelonado cacao at Tafo and Bunso Plantations, and on Upper Amazon cacao at Akwadum Substation. Assessment of the effect of treatments is being made by direct capsid counts and by the amount of damage observed.

In the experiment at Tafo, much higher capsid populations (almost entirely Distantiella theobroma) have been recorded in the plots containing unpruned cacao than in those containing pruned cacao, irrespective of the type of insecticidal treatment which they have been receiving (an average of 15 capsids per 100 trees per visit in unpruned plots compared with 2 in pruned plots). This effect is also reflected in the amount of damage which has been recorded (15 damaged shoots per 100 trees per visit in the unpruned plots compared with 5 in the pruned plots). For the pruned plots there appears to be no significant difference between the insecticidal treatments; the localised application of 5% DDT dust to recently damaged trees and the thrice yearly application of 1.25% DDT aqueous emulsion have been equally effective (2.1 capsids per 100 trees per visit in liquid-treated plots and 1.7 in dust-treated plots). However, for the unpruned plots more capsids were recorded on trees which received the dust treatment than on those which received the liquid application (19 capsids per 100 trees per visit in dust-treated plots compared with 11 in liquid-treated plots). Yield data, to elucidate the effect of pruning on yield, will not be available until next season's crop has been harvested.

In the experiment on the Upper Amazon cacao at Akwadum Substation, the only treatment difference which has become apparent is that, on the basis of capsid counts, insecticidal dusting of unpruned trees is less efficient than routine liquid applications.

The experiment at Bunso Plantations, while basically the same as the other two, is more comprehensive and contains treatments to test various frequencies of application of the insecticides. No treatment differences have been observed so far this season, because capsid damage has been negligible throughout the area.

(f) Capsid Ecology

Estimation of Population

The routine counts in the Tafo area have indicated that population peaks for both Distantiella theobroma and Sahlbergella singularis were attained in September. A population index of 28 capsids per 100 trees was recorded for D. theobroma in that month and since then the population has declined slowly to an index of 21 capsids per 100 trees in December. A similar fall in the population has been recorded in the Ecological Study Plots in the Square Mile. The population index for S. singularis in September was 11 capsids per 100 trees, and during October and November it fell to 7 capsids per 100 trees. The population rose again sharply in December to 10 capsids per 100 trees, a trend which was also recorded in the Ecological Study Plots.

The .../

The use of light-traps incorporating mercury-vapour discharge lamps, which emit light rich in the ultra-violet wavelength, has been continued. The method is effective in trapping S. singularis; D. theobroma, however, is not attracted by the light. Fluctuations in monthly estimates of the S. singularis population obtained by this method follow closely the population counts made in one of the Ecological Study Plots, situated some five hundred yards from the light-trap. The pattern is also similar to that shown by the routine counts. Thus, the available evidence suggests that light-trapping is a valid method of sampling the S. singularis population.

Two experiments are being laid down, one at Akwadum and one at Tafo, to investigate the possibilities of population estimation by egg counts. Fan and chupon tissue will be sampled and examined for eggs at fortnightly intervals on some plots, whilst on others capsid counts are to be made. Correlation between the two sets of figures obtained will be studied. The proportionate utilisation of fan and chupon tissue for oviposition and the vertical distribution of oviposition sites on mature trees are also being investigated.

(g) Investigation of Fungi Associated with Capsid Lesions

Identity and Relative Importance

The experiment on the relative importance of the fungi associated with capsid lesions, described in the 39th Quarterly Report, has continued and the results to date are presented below :-

FUNGUS	CAPSID LESIONS INFECTED (%)				
	*Young	Medium	Old	Occluded	Total
Fusarium decemcellulare	-	15.8	10.3	1.4	5.7
Fusarium spp.	12.5	9.2	17.9	7.5	10.1
Botryodiplodia theobromae	17.9	27.6	35.9	47.6	36.2
Other fungi	51.7	42.1	28.2	37.4	39.9
Apparently sterile	17.9	5.3	7.9	6.1	8.2

*'Young' = newly formed lesions.

'Medium' = lesions older but not beyond the stage when phloem fibres become exposed.

'Old' = from the medium stage until the lesions begin to be occluded.

'Occluded' = lesions in the wood of trunks up to 3 ft. above soil level. (These were examined in conjunction with the experiment described in the 39th Quarterly Report, Section 4a).

A .../

A total of 295 lesions have been examined, 0.74% of which appeared to be infected by more that one fungus.

Dissemination

In continuation of investigations into the possibility of the fungi being carried by capsids themselves (see 39th Quarterly Report) 216 of these insects, collected from the field, have now been examined, using the method already described. Fusarium decemcellulare Brick was isolated from 11% of them, other Fusarium spp. from 23%, Botryodiplodia theobromae Pat. from 9%, and other fungi from 98%; only a single capsid appeared to be uncontaminated. Latterly, since it is of interest to know on which parts of the insect the fungi are carried, the legs, mouthparts and bodies of 73 of them have been plated out separately. F. decemcellulare has not yet been demonstrated on the mouthparts of either Sahlbergella singularis or Distantiella theobroma. The percentage contamination of different parts of the insects with various fungi is given below :-

FUNGUS	LEGS	BODIES	MOUTH-PARTS	TOTAL
Fusarium decemcellulare	2.6	1.9	-	1.7
Fusarium spp	8.2	11.8	6.8	9.1
Botryodiplodia theobromae	1.5	0.6	-	0.9
Other fungi	87.6	85.1	68.6	82.0
Uncontaminated	-	0.6	24.6	6.3

Effect of Environment on Host Reactions

A trial has been laid out on four-month-old seedlings in baskets to examine the effect of fertilizers and different levels of watering on the development of lesions caused by inoculating F. decemcellulare into cacao stems, using a dissecting needle. It has been shown that to ensure infection by this method the needle must penetrate into the wood.

Cultural Studies

Experiments on the growth of F. decemcellulare on cassava-dextrose agar have shown a positive correlation ($P = 0.05$) between the final diameter of a colony after 10 days' growth and its dry weight; but there was no correlation between daily increases in diameter and dry weight. In 20 ml. of a liquid medium made from cassava and dextrose, growth (as measured by dry weight) followed the normal curve, the staling effect becoming obvious after 10 days.

When colonies on cassava-dextrose agar were subjected to continuous darkness or illumination the usual colour zonation did not develop, and the longer they were illuminated per day

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the darker the pigmentation. Illumination had no effect on the size or septation of macrospores or on the size of microspores.

In Richard's solution of pH range 3.3-7.0 there was limited growth below pH 5.6; above this the medium eventually became stabilised at pH 6.3-6.6 by the growth of the fungus, which was greatest at pH 6.4. With initial pH values between 3.3 and 7.0 the length of macrospores increased from 53 to 71, but there was no significant difference in their septation; the size of microspores was uniform. The medium was acidified with N/10 HCl or made more alkaline with approximately N/10 NaOH; above pH 7 a precipitate formed, possibly $Mg(OH)_2$.

Some information on the nutrient requirements of the fungus has been obtained by suitably modifying Richard's solution, or a solid medium made from it by addition of agar-agar. The daily increase of growth in solid medium or final dry weight of mycelium after 10 days' growth in liquid medium were not greatly affected by changes in C/N ratio, brought about by altering the concentrations of sucrose or KNO_3. At a sub-normal nitrogen level, growth was better on a medium with twice the normal concentration of other nutrients. Using four different nitrogen sources, it has been shown that growth is greatly reduced by the presence of the NH_4 ion; NH_4NO_3 was better than $(NH_4)_2SO_4$, but both these ammonium salts were greatly inferior as nitrogen sources to KNO_3 or amino-acetic acid, which were comparable.

Spores of F. decemcellulare were subjected to different temperatures for various periods to determine their upper thermal death point. The germination rate after 24 hours in distilled water fell from 9% for 5 minutes heating at 45°C. to 0% after 25 minutes at 60°C.

The method of development of both macrospores and microspores has been elucidated: the latter develop basipetally, as do the septa of the former.

5. EXPERIMENTS ON ESTABLISHMENT AND MAINTENANCE

Routine maintenance has been carried out on the following projects, which are listed in the Research Programme :-

(a) Establishment Trials; (b) Spacing Trials; (d) Comparative Yield Trials of Seedlings and Cuttings; (e) Effect of Soil Type on Pod Development and Yield; (f) Methods of Forecasting Yields of Cocoa; (g) Effect of Removal and Retention of Chupons on Rooted Fan Cuttings; (h) Frequency of Picking Experiments.

In some of these trials the trees have not yet come into bearing, and in the remainder the season's yield figures are incomplete.

(c) Shade Trials and Observations

Forty 18-tree plots, twenty of which are under fairly dense oil-palm shade and twenty under light forest shade, have been recorded for yield in terms of pods and wet-bean weight.

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The figures have not yet been analysed, but the aggregate yield from trees under light shade is 2.6 times greater in terms of pods and 2.7 times greater in terms of wet-bean weight than for those under oil-palm shade.

6. SOIL FERTILITY AND MANURIAL REQUIREMENTS

(a) Effect of Amounts and Combinations of Major Nutrients

The application of fertilizers to all experiments has been continued, and girth measurements are now being made on all seedlings.

(g) Investigation of Factors Limiting Growth in the Early Life of Cacao Seedlings

The removal of shade from all four blocks of this experiment has been completed, and the seedlings continue to show a marked response to light.

7. VEGETATIVE PROPAGATION

Alternative rooting media have been tried to replace palm fibre, which is apt to be in short supply. Results show that composted wood, sawdust and elephant grass are all excellent media in a 50% admixture with coarse sand, and can be used if supplies of palm fibre are exhausted.

Further work has been carried out with polythene sheeting in an effort to provide a reliable but simple and inexpensive method of propagation. Experiments are designed to improve details of the present successful method and raise the rooting percentage to as high a level as possible. To obviate the danger of damaging roots while transplanting it has been found useful to put the cuttings into paper pots to root. The whole pot can then be transferred to a basket, complete with the rooted cutting. Another method at present being tried out is to root and harden the cutting in the same basket, under the polythene sheeting.

8. PLANT BREEDING

(a) Established Trials

Main-crop harvesting has practically finished now in all trials. Yields are probably slightly lower than in the previous year. The yield from the 8th P.T.A. (planted April - May 1952) in pods per tree was as follows :-

WE	WA	WB	WAE	WBE
2.09	0.02	0.15	1.18	1.53

While the hybrids are slightly less prolific than Upper Amazons, there is evidence that they have combined early vigour with good bean size and flavour.

(c) .../

(c) Variety Trials on Out-Stations

Pod distribution has continued for the Series II Variety Trials on Gold Coast Cocoa Stations. Pods have been scarce for a number of reasons and only four trials will be planted in 1956; the remaining four will be planted in 1957. Plans have been made to lay down two Variety Trials in Nigeria in 1956, with further trials in 1957.

Routine maintenance has been carried out on the Series I Variety Trials.

9. COCOA FERMENTATION AND QUALITY

(a) Fermentation and Chemical Constitution

Fermentation

The first part of the study on methods of small-scale bulk fermentation is almost finished. The results cannot, however, be correlated until the last experiments have been completed and the raw cocoa made into chocolate for tasting tests.

Changes in the Polyphenolic Components during Fermentation

In each of the fermentations carried out, the bean mass was sampled daily and the various groups of polyphenolic compounds analysed quantitatively by the paper-chromatographic technique described in the 39th Quarterly Report. Considerable changes occur in these compounds and their destruction is in some measure dependent on the conditions of fermentation.

Experiments on the Drying of Fermented Cocoa

As a continuation of the work on fermentation, quantitative estimations of the polyphenolic compounds have been made during drying.

(b) Effect of Drying Conditions on Purple-Bean Counts

The influence of drying conditions on the purple-bean content of fermented cocoa is being studied by making weekly counts on every batch on the drying frames. The moisture content is also being checked weekly and records kept of atmospheric conditions during each drying.

(c) Survey of Farmers' Fermentation Methods

Samples have been received from 110 of the farms selected and the beans are being cut for analysis as they arrive.

VISITING SCIENTISTS

Dr. G.R. Howat, Dr. P.B. Powell and Mr. G.A.R. Wood of Messrs. Cadbury Brothers spent some weeks at the Institute during the quarter, carrying out experiments on fermentation.

12. .../

12. PHYSIOLOGY OF NUTRITION, GROWTH AND FRUITING

(a) Root Studies

(i) Monthly sampling of seedlings continues in the experiment on root growth of seedlings on different soil types. The plants on the Koforidua Series are larger and heavier than those on the Akwadum Series, but the latter have longer tap roots.

(ii) In the experiment to test the effect of over-cropping in the early years on subsequent bearing and root growth, yields were light, and 70% of the crop was harvested from the edge rows of the plot. This suggested that shade was too dense, so it has been reduced.

(e) Investigation of Cherelle Wilt

The experiment on flush prevention has been completed, and although the 39th Quarterly Report mentioned a 90% increase in yield of pods from trees on which flushing was prevented, the final figures show no difference between treatments. This is due to earlier cropping on the treated trees compared with the controls. Wet-bean weight per pod was 158.31 gm. for the treated trees and 171.01 gm. for the controls. This difference is significant at the 0.1% level. Thus, it would seem that although the number of pods harvested was unaffected by lack of carbohydrates, it reduced the weight of cocoa per pod. The experiment suggests that cherelle wilt is not associated with carbohydrate supply.

This evidence, combined with previous results, raises the question of whether cherelle wilt is caused by lack of nutrients and whether it is true that a tree can only produce as many ripe pods as its nutrient supply allows. Work is proceeding in an effort to estimate growth substances in pods of all sizes, and while no pattern has yet emerged, both growth promoters and growth inhibitors have been extracted. These are being estimated using the bio-assay method of Archibald (34th Quarterly Report).

(ii) Extensive data on factors limiting yield have been collected from the 1st Clonal Trial and are now being analysed.

(iii) Maleic hydrazide (0.1%) has not proved effective in delaying flushing on mature cacao, although it is extremely effective on seedlings. The experiments on mature cacao are being repeated.

(iv) Spraying with naphthalene acetic acid (NAA) has given no reduction in the amount of cherelle wilt. At 1000 ppm. NAA caused thinning of young cherelles but gave no increase in yield. No acceleration in ripening was caused by spraying this substance on full-grown pods. The data from this series of experiments are being compiled and analysed.

(v) No success has been achieved in the experiments designed to induce cherelle wilt in the laboratory; the pods never showed the same type of wilt symptom as in the field.

(vi) .../

(vi) The male parent of a cross has been found to have no influence on the degree of cherelle wilt, the percentage of pods wilting on any given tree being constant irrespective of the pollen source.

IBADAN SUB-STATION

1. VIRUS RESEARCH

(c) Classification of Viruses and Virus Strains

Heat Treatment of Virus-Infected Plants

A number of cacao seedlings infected with different virus isolates have been grown at a controlled temperature of 38°C. for periods up to four weeks. This treatment appears to have had little effect on symptom expression.

Stem cuttings from mosaic-infected cassava plants have been grown in our high temperature chamber for the mycologist of the Nigerian Federal Research Organisation. The new growth made during treatment was symptomless, and has remained so for 4 weeks after transfer to the glasshouse.

Effect of Virus Infection on Growth of Seedlings

A number of experiments have now been recorded and analysed for the effect of various Nigerian cacao-virus isolates on the growth of cacao seedlings. Infection greatly reduced the leaf area and rate of growth of seedlings infected by the bean-feeding technique.

Comparison of Yields from Infected and Healthy Trees

A comparison of the yields of infected and healthy trees in the Koroboto and Offa Igbo Observation Plots has been made, using records for the season August 1954 - July 1955. The data for Koroboto are summarized in Table I, which indicates that the yield of trees which had shown symptoms for one year or more was considerably less than that of apparently healthy ones. This difference would probably have been greater if "black pods" had been taken into consideration, since black pod disease in Nigeria has been shown to vary in proportion to the number of pods per tree (Thorold in Journal of Ecology, 40, p.125). There was no evidence that pods from infected trees contained a smaller weight of beans than those from healthy trees. It is hoped to extend this work to a number of observation plots throughout the areas affected by cacao viruses, recording only total numbers of pods, including those damaged by animals and Phytophthora palmivora.

(i) Coppicing Experiments

I.N.A. Farm

Most of the coppiced trees on the old spacing trial at I.N.A. Farm have now been regenerating for at least a year and vigorous growth continues on most of the plots. Many of

the .../

TABLE I

THE EFFECT OF A NIGERIAN CACAO SWOLLEN SHOOT VIRUS ON YIELD

KOROBOTO PLOT

Category	Number of trees	Yields per tree excluding damaged pods - 1954-55					
		Number of pods		Weight of pods ø		Weight of wet beans ø	
		Mean	S.E. of mean	Mean	S.E. of mean	Mean	S.E. of mean
1. Trees without symptoms +	98	16.1	1.9	13.2	1.5	3.78	.43
2. Trees which showed symptoms Sept. 1954-Oct. 1955	69	16.6	2.6	13.4	1.9	3.86	.54
3. Trees which showed symptoms Sept. 1953-Sept. 1954	52	11.0*	2.0	9.4	1.7	2.71	.46
4. Trees which showed symptoms before September 1953	49	8.8**	1.7	7.4**	1.5	2.19**	.42

\+ A random sample of the 657 symptomless trees, omitting 'contact' trees.

** Yield significantly different from symptomless trees (P =.01).

* Yield significantly different from symptomless trees (P =.05).

ø Weights are given in lb.

the chupons have produced a jorquette, and some are bearing flowers and a few cherelles. The growth made by regenerating chupons is correlated with the girth of the trees at the time of coppicing. This is illustrated in the Table below, which summarizes the data obtained from two adjacent one-acre plots which were coppiced in August 1954, and on which chupon heights were measured in March 1955 :-

Girth at time of coppicing	Number of trees	Average growth of chupons*
1" - 4"	44	17"
5" - 8"	93	22"
9" - 12"	95	34"
13" - 16"	156	41"
17" - 20"	336	44"
21" - 24"	88	47"

* Four chupons were allowed to grow from each stump.

The growth of chupons from stumps of the largest trees was almost three times that from those of the smallest, and recent observations on chupon girth indicate that the differences have been maintained. Better growth from larger stumps may be due to greater nutrient reserves, giving an advantage in the initial stages of regeneration which persists; though a more likely explanation is that chupon growth depends upon the available root system. Moreover, sites which supported the largest trees are likely to be inherently more favourable for the growth of cacao.

Initial regeneration on the plots coppiced in May and June, 1955, was disappointing and many of the chupons died at an early stage, while others showed severe and premature leaf abscission associated with the persistence of leaf stipules (see previous Quarterly Reports). Most of the chupons showing this 'paint-brush' effect have now recovered by the development of apparently normal axillary buds, and renewed cushion activity has produced further chupons on stumps on which the originals died. Recovery became evident in October and growth is now healthy and vigorous. The 'paint-brush' condition has been found on other areas coppiced at the time of the early rains and the syndrome is strikingly similar to the leafless-twig disease of cacao in the Cameroons. A sample of trees is coppiced every fortnight at I.N.A. Farm in an experiment to investigate seasonal effects on regeneration, and data on the appearance of 'paint-brush' are summarized below :-

Coppicing .../

Coppicing date	Number of trees coppiced	Percentage of stumps with chupons showing 'paint-brush'	Rainfall in month after coppicing
13/12/54	65	0	0.12"
28/12/54	68	0	0.20"
14/ 1/55	50	0	0.52"
29/ 1/55	63	0	0.32"
12/ 2/55	72	0	1.23"
24/ 2/55	70	1	5.49"
8/ 3/55	61	2	11.39"
25/ 3/55	60	7	9.28"
8/ 4/55	50	20	5.61"
21/ 4/55	60	28	4.48"
5/ 5/55	50	32	5.43"
20/ 5/55	47	30	9.05"
2/ 6/55	48	48	7.97"
15/ 6/55	48	48	9.38"
1/ 7/55	40	25	5.76"
14/ 7/55	47	19	5.91"
27/ 7/55	46	20	2.20"
8/ 8/55	41	24	3.53"
24/ 8/55	47	9	8.89"

It will be seen that the appearance of chupons with 'paint-brush' was associated with the onset of the rainy season; but there was no clear correlation with rainfall after coppicing, and no chupons on stumps coppiced after 24/8/55 were found with symptoms, although the rains continued until November.

Owena Farm

Routine recording of the Owena coppicing experiments has continued and excess chupons have been pruned off.

Araromi Experiment

The outbreak of cacao virus at Araromi was coppiced in May 1955, and monthly observations have been made on the appearance of symptoms on chupons growing from the stumps. To date, 40 infected stumps have died and chupons on 10 of the remaing 73 have so far failed to give symptoms. This may mean that the virus was not completely systemic in all the standing trees at the time of coppicing, or that very mild strains have become dominant in some of the stumps. Further work is being planned to clarify this point. Symptoms have been observed on chupons from 39 trees which were symptomless at the time of coppicing.

Control .../

Control of Cacao Swollen Shoot Virus

The Cocoa Survey Division of the Department of Agriculture is now dealing with virus outbreaks by removing all infected trees and apparently healthy ones immediately adjacent. Remaining trees are coppiced to a distance of thirty yards from known infections and the new growth is subsequently inspected for virus symptoms. Forty outbreaks have been treated in this way within the last year and information is being collected on the number and distribution of latent infections revealed by coppicing.

2. MEALYBUG STUDIES

The Tafo and Ibadan collections of mealybug parasites and predators have been re-examined in the light of information obtained during the Entomologist's recent visit to the Commonwealth Institute of Entomology. A collection of parasites in certain genera of particular interest to taxonomists in the United Kingdom has been prepared for despatch. The Entomologist has written up his earlier work on the natural enemies of some Pseudococcidae in the Gold Coast, and the paper has been accepted by the Journal of the West African Science Association.

4. CAPSID STUDIES

Two field experiments on capsid control are to be inaugurated in the Western Region.

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